

Claims

- [c1] 1. A system for controlling exhaust emission oxides of nitrogen (NOx) during restarts of an internal combustion engine (ICE), the system comprising:
 - a first sensor for determining a first level of exhaust gas oxygen at a location upstream of a catalytic converter;
 - a second sensor for determining a second level of exhaust gas oxygen at a location mid-bed of the catalytic;
 - and
 - a controller for performing at least one process to reduce NOx emissions when a difference between the first level of exhaust gas oxygen and the second level of exhaust gas oxygen exceeds a predetermined amount.
- [c2] 2. The system set forth in claim 1 wherein the at least one process to reduce NOx emissions comprises delaying an engine restart for a predetermined time.
- [c3] 3. The system set forth in claim 1 wherein the at least one process to reduce NOx emissions comprises limiting the number of restarts to a predetermined number during a selected interval of time.
- [c4] 4. The system set forth in claim 1 wherein the at least

one process to reduce NOx emissions comprises minimizing pumped oxygen.

- [c5] 5. The system set forth in claim 4 wherein minimizing pumped oxygen comprises closing a throttle during shutdown.
- [c6] 6. The system set forth in claim 1 wherein the at least one process to reduce NOx emissions comprises providing rich fueling during the engine restart condition to re-condition the catalytic converter.
- [c7] 7. The system set forth in claim 1 wherein at least one of the first and second levels of exhaust gas oxygen are determined using a heated exhaust gas oxygen (HEGO) sensor.
- [c8] 8. The system set forth in claim 1 wherein at least one of the first and second levels of exhaust gas oxygen are determined using a universal exhaust gas oxygen (UEGO) sensor.
- [c9] 9. The system set forth in claim 1 wherein the catalytic converter is a three-way catalytic converter (TWC).
- [c10] 10. A system for controlling exhaust emission oxides of nitrogen (NOx) during restarts of an internal combustion engine (ICE), the system comprising:

a first sensor for determining a first level of exhaust gas oxygen at a location mid-bed of a catalytic converter; a second sensor for determining a second level of exhaust gas oxygen at a location downstream of the catalytic converter; and a controller for performing at least one process to reduce NOx emissions when a difference between the first level of exhaust gas oxygen and the second level of exhaust gas oxygen exceeds a predetermined amount.

- [c11] 11. The system set forth in claim 10 wherein the at least one process to reduce NOx emissions comprises delaying an engine restart for a predetermined time.
- [c12] 12. The system set forth in claim 10 wherein the at least one process to reduce NOx emissions comprises limiting the number of restarts to a predetermined number during a selected interval of time.
- [c13] 13. The system set forth in claim 10 wherein the at least one process to reduce NOx emissions comprises minimizing pumped oxygen.
- [c14] 14. The system set forth in claim 13 wherein minimizing pumped oxygen comprises closing a throttle during shutdown.
- [c15] 15. The system set forth in claim 10 wherein the at least

one process to reduce NOx emissions comprises providing rich fueling during the engine restart condition to recondition the catalytic converter.

- [c16] 16. The system set forth in claim 10 wherein at least one of the first and second levels of exhaust gas oxygen are determined using a heated exhaust gas oxygen (HEGO) sensor.
- [c17] 17. The system set forth in claim 10 wherein at least one of the first and second levels of exhaust gas oxygen are determined using a universal exhaust gas oxygen (UEGO) sensor.
- [c18] 18. The system set forth in claim 10 wherein the catalytic converter is a three-way catalytic converter (TWC).
- [c19] 19. A system for controlling exhaust emission oxides of nitrogen (NOx) during restarts of an internal combustion engine (ICE), the system comprising:
 - a first sensor for determining a first level of exhaust gas oxygen a location upstream of a three-way catalytic converter (TWC);
 - a second sensor for determining a second level of exhaust gas oxygen at a location mid-bed of the TWC;
 - a third sensor for determining a third level of exhaust gas oxygen a location downstream of the TWC; and

a controller for dynamically monitoring the exhaust gas oxygen level at the locations in the exhaust system and performing at least one process to reduce NOx emissions when a difference between the levels of exhaust gas oxygen exceeds a predetermined amount.

- [c20] 20. The system set forth in claim 19 wherein the process to reduce NOx emissions comprises at least one of delaying an engine restart for a predetermined time, limiting the number of restarts to a predetermined number during a selected interval of time, minimizing pumped oxygen, and providing rich fueling during the engine restart condition to recondition the catalytic converter.